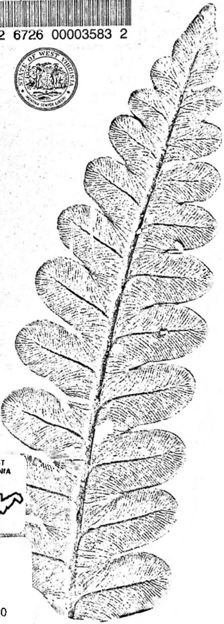

A GUIDE TO THE COMMON FOSSIL PLANTS OF WEST VIRGINIA

By
W. H. Gillespie
and
I. S. Latimer, Jr.

WEST VIRGINIA
GEOLOGICAL
AND
ECONOMIC SURVEY
Paul H. Price, Director
and State Geologist

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LETTER OF TRAMSMITTAL

Honorable Cecil H. Underwood,
Governor of West Virginia and President,
Geological and Economic Survey Commission,
Charleston, West Virginia

DEAR SIR:

I have the honor to submit for publication an addition to our Educational Series entitled "A Guide to the Common Fossil Plants of West Virginia," by Mr. W. H. Gillespie, of the West Virginia University Geology Department, and Mr. I. S. Latimer, Jr., Assistant Coal Geologist of our Survey.

I believe that one of the primary objectives of the Geological Survey is to aid the public in gaining an understanding of the geology of our State. Previous publications in this Series have covered rocks and minerals; natural resources; coal and oil and gas; and now this latest volume on the fossil plants that are so abundant in West Virginia coals and associated rocks.

The Geological Survey receives many requests for information on these fossil materials. In this volume, the common fossil plants have been fully described and illustrated to fill the needs of the average person who has little or no training in this field.

Respectfully submitted,

PAUL H. PRICE, *Director*
and State Geologist.

Morgantown, W. Va.
June 30, 1960

CONTENTS

FIGURES

PLATES

A GUIDE TO THE COMMON FOSSIL PLANTS OF WEST VIRGINIA

INTRODUCTION

Fossils are the remains of organisms that lived and died many thousands of years ago and which were buried in protective deposits of mud or sand that has since become consolidated into rock. Technically, the term fossil is limited to those organisms that are at least as old as the "ice ages"—thereby excluding the buried remains of our present day life. The science of the study of fossil plants is **Paleobotany.**

Although fossil plant impressions have been seen in mines and quarries and on slate dumps and spoil banks since the mining industry first began, it is only in recent years that they have attracted the attention of the non-professional workers. The fascination and thrill of breaking open a rock and finding the remains of a plant which has been extinct for millions of years is a rewarding experience. Who knows, but what the next blow may uncover a plant never before seen by man, or one which will materially aid in deciphering the earth's history? This anticipation of the unknown has been communicated and extended in recent years by high school biology teachers who conduct "fossil hunts" with their classes, and by mining and industrial fairs which often offer lucrative prizes for the best fossil exhibit. This interest is perhaps accelerated even more by the fact that the humblest collector has just as good a chance of finding unique specimens as does the most highly trained specialist.

This publication has been prepared to help satisfy the many dozens of requests received each year for semitechnical information about the fossil plants of West Virginia. It is our hope that this effort will make it easier for the people of West Virginia, as well as those of surrounding areas, to better understand and appreciate the plants which represent part of the earth's past history. This booklet is not intended as an exhaustive treatise of the fossil plants in West Virginia, but rather as a guide to the more common generic forms.

The authors wish to express their appreciation to Dr. Paul H. Price, Director and State Geologist of the West Virginia Geological Survey, for his advice and interest during the preparation of this publication, and to Mr. Carl M. Ailara for preparing the reconstructions and various line drawings.

KINDS OF FOSSILIZATION

Plants or fragments of plants were preserved in several different ways. The most common method was by burial in

mud or sand, on the floor of seas or swamps, which later became rock. However, in some parts of the world the rapid deposition of volcanic ash entombed and preserved large acreages of ancient forests, and in other areas plant fragments settling in ancient lakes were preserved in the calcareous ooze of the bottom.

For all practical purposes, plant fossils can be classified into three main categories. These are compressions and impressions, petrifactions, and casts and molds.

Compressions and Impressions

This form of preservation is perhaps the most common of the three mentioned above. In this method, plant fragments, such as leaves, twigs, and seeds, fell into the water, became waterlogged, and sank to the bottom of the swamp or lake where they were covered with clay, sand, or other fine sediments. The gradually increasing weight pressed out the water and air present in the plant organs, and the organic substance gradually became converted into a coaly material while the surrounding sediment was being consolidated into shale or sandstone. Upon splitting such rocks open we find frequently that one side or surface will contain a nearly intact "compression" of the plant fragments while the other shows an impressed counterpart. These are the positive and negative sides, respectively.

Spores and Pollen:

The spores and pollen of extinct plants were covered by a layer of organic material much the same as in present-day species. This material proved so resistant to destruction that these microscopic plant bodies were preserved by the millions. Of course, no one sees such fossils with the naked eye, but when coal is chemically treated, screened, and the resulting residue examined under a microscope, they can be seen very clearly (Fig. 1). They are separated rather easily from coal samples, and proper techniques also reveal their presence in limestones, sandstones, and shales. Literally, they are minute compressions.

Casts and Molds

A mold was formed when a plant organ, usually some bulky part, such as a root, seed, or stem, was buried in loose sand or mud and decayed as the sediment hardened around it. The cavity which was left was an exact mold of the outside of the object, showing both its size and shape. Sometimes this mold or cavity was later filled with other mineral matter which hardened and thus formed a cast of the original plant (Plate 1).

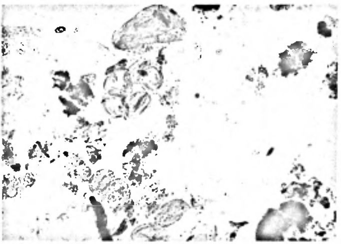


FIGURE 1.—Fossil plant spores extracted from coal (X 500).

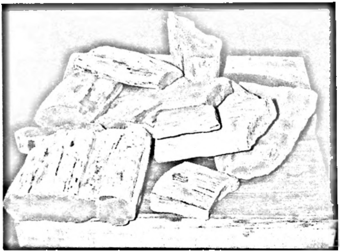
Petrifactions

This third type of fossil is the rarest and quite often the most important because the internal cell structure is preserved and thus can be studied. When petrifaction began, the plant fragments were apparently immersed in water containing mineral substances in solution. As the plant parts became saturated, the mineral substances gradually separated out of solution and were deposited as a solid filling in the cells. At the same time the water in the cells was being expelled by the compaction of the overlying sediments. This resulted in the solidification of the sediments and the enclosed plant organs, thus completing the petrifaction process (Figs. 2 and 3).

WHERE TO FIND FOSSILS

A common question is, where do you find plant fossils? Of course, there is no really definite answer, but in West Virginia a majority of such plants are likely to be found in the rocks associated with coal seams (see Figs. 4 and 5). This is not to be interpreted as being the only place where one should look, for excellently preserved fragments are sometimes found in rock and clay quarries or in drill cores, but never in such abundance or so nicely preserved as around mines.

FIGURE 2.—Petrified logs.



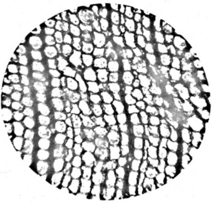


FIGURE 3.—A greatly magnified section from a fossil log showing that cell structure is often preserved.

After a little experience, the collector will learn the locations and types of rock that are most likely to yield plant remains. A beginner will probably meet with more certain success if he will search in the shaly rocks that occur just above most coals, or in the partings that often separate the individual benches of the seam. The collector can dig this material from an outcrop or exposure (Fig. 6) such as can be found in a railroad or highway cut. However, it is usually easier and more productive to split open the blocks of refuse rock that are piled in "dumps" near the mouths of many deep mines, or that are found in profusion on any strip mine (Fig. 6). It is futile to attempt to collect fossil plants on burning "dumps" because the carbonaceous film representing the plant remains burns very quickly.

Almost anywhere that you may wish to collect will be on private land; so always obtain permission from the owner before entering the property. This is important not only as a matter of courtesy, but also as a safety precaution. In operating quarries and strip mines, explosives and heavy machinery often constitute hazards, while abandoned workings may be even more dangerous. One should never enter

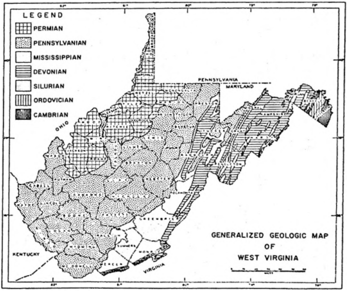


FIGURE 4.—Geologic map of West Virginia.

<table>
<tr><th>ERA</th><th>SYSTEM</th><th colspan="2">SERIES AND GROUPS</th><th>IMPORTANT COAL SEAMS</th></tr>
<tr><td rowspan="8">PALEOZOIC (UPPER)</td><td rowspan="2">PERMIAN</td><td rowspan="2">DUNKARD SERIES</td><td>GREENE GROUP</td><td>NO SEAMS PRESENTLY OF VALUE</td></tr>
<tr><td>WASHINGTON GROUP</td><td>WASHINGTON</td></tr>
<tr><td rowspan="6">PENNSYLVANIAN</td><td colspan="2">MONONGAHELA SERIES</td><td>WAYNESBURG ◄
SEWICKLEY
REDSTONE
PITTSBURGH ◄</td></tr>
<tr><td colspan="2">CONEMAUGH SERIES</td><td>ELK LICK
BAKERSTOWN ◄
MAHONING</td></tr>
<tr><td colspan="2">ALLEGHENY SERIES</td><td>UPPER FREEPORT ◄
LOWER FREEPORT
UPPER KITTANNING ◄
MIDDLE KITTANNING ◄
NO. 5 BLOCK
CLARION</td></tr>
<tr><td rowspan="3">POTTSVILLE SERIES</td><td>KANAWHA GROUP</td><td>UPPER MERCER
STOCKTON ◄
COALBURG
BUFFALO CREEK
WINIFREDE
CHILTON
THACKER
HERNSHAW
WILLIAMSON
CEDAR GROVE
LOWER CEDAR GROVE
ALMA
PEERLESS } CAMPBELL CREEK ◄
NO. 2 GAS }
POWELLTON
EAGLE
LITTLE EAGLE
LOWER WAR EAGLE
GILBERT
DOUGLAS</td></tr>
<tr><td>NEW RIVER GROUP</td><td>IAEGER
SEWELL "B"
SEWELL ◄
WELCH
LITTLE RALEIGH
BECKLEY ◄
FIRE CREEK
NO. 9 POCAHONTAS</td></tr>
<tr><td>POCAHONTAS GROUP</td><td>NO. 7 POCAHONTAS
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NO. 2 POCAHONTAS</td></tr>
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FIGURE 5.—Geologic position of the important coal seams of West Virginia. The best collecting horizons are indicated.

FIGURE 6.—Two excellent places to collect fossil plants: top, shales above outcropping coal seams; bottom, shale blocks left by strip mining operations.

abandoned drift mines or walk close under the highwall of a strip mine—regardless of permission—because the rocks tend to break up during weathering and often fall without warning.

GEOLOGIC TIME

Throughout geologic[1] time, ever since the original molten mass of rock began to cool and form a solid crust, the agents of weathering have been continuously breaking down rocks into mineral particles and solutions. These have been deposited in lakes and streams where, after compaction and cementation, they became sandstone, shale, limestone, or clay. Rocks formed in this manner are called sedimentary rocks; they contain most of the fossil record.

It is important in any historical study to discover the sequence of events which have followed one another, in order to correctly assign reasons for any particular happening. Since life on earth has been constantly evolving, the animals and plants have changed from age to age. This succession of plant and animal life together with the various rock types has provided the geologist with one basis for charting the history of the earth. This history, when placed in chronological sequence, is known as the geologic time chart (Fig. 7). The largest subdivisions are called eras, and each is respectively divided into smaller and smaller units corresponding to periods of time, and ultimately into particular formations or units such as the Redstone Coal or the Uffington Shale.

Most of the fossil plants in West Virginia are found in rocks of the Pennsylvanian System, which were deposited about 250 million years ago.

THE FORMATION OF COAL

Since a majority of the fossil plants to be found in West Virginia are in close association with coal seams, it is perhaps worth while to discuss briefly the origin of coal.[2]

It is quite generally recognized that coal is formed from chemically and physically altered plant debris, so the first stage in coal formation is the growth and accumulation of plants. In our modern forests, plant debris is constantly falling to the ground, but it seldom accumulates in any appreciable amount because of decay. For example, if a tree is left lying upon the ground, it is attacked at once by the destructive forces of fungi, bacteria, insects, and other agencies which, in time, reduce it to a rotten mass and ultimately to dust. If, however,

[1] The science of the study of rocks is Geology, and those who work in this field are geologists.

[2] A more thorough discussion can be found in "Coal and Coal Mining in West Virginia", by Oscar L. Haught, published by the West Virginia Geological Survey.

ERA	PERIOD	AGE*	DOMINANT LIFE	
			PLANTS	ANIMALS
CENOZOIC	*QUATERNARY*	1	MODERN FLORAS	MAN APPEARS
CENOZOIC	*TERTIARY*	70	HERBACEOUS PLANTS RISE, FORESTS & GRASSES SPREAD	MODERN MAMMALS APPEAR & DEVELOP
MESOZOIC	*CRETACEOUS*	130	ANGIOSPERMS RISE, GYMNOSPERMS DECLINE	DINOSAURS REACH PEAK, FIRST SNAKES APPEAR
MESOZOIC	*JURASSIC*	170	CYCADS PREVALENT	FIRST BIRDS AND MAMMALS APPEAR
MESOZOIC	*TRIASSIC*	200	GYMNOSPERMS RISE, SEED FERNS DIE OUT, ANGIOSPERMS APPEAR?	REPTILES PROMINENT
PALEOZOIC	*PERMIAN*	225	CONIFERS & CYCADS	REPTILES DOMINANT, FIRST BEETLES AND LAND VERTEBRATES
PALEOZOIC	*PENNSYLVANIAN*	250	LEPIDODENDRON, SIGILLARIA AND CALAMITES DOMINANT	AGE OF COCKROACHES, FIRST REPTILES
PALEOZOIC	*MISSISSIPPIAN*	280	LYCOPODS ABUNDANT	PEAK OF CRINOIDS AND BRYOZOANS
PALEOZOIC	*DEVONIAN*	335	FIRST SPREAD OF FORESTS	FIRST AMPHIBIANS, INSECTS & SPIDERS
PALEOZOIC	*SILURIAN*	375	FIRST KNOWN LAND PLANTS	FIRST AIR BREATHERS
PALEOZOIC	*ORDOVICIAN*	450	ALGAE	PEAK OF TRILOBITES, FIRST FISHES
PALEOZOIC	*CAMBRIAN*	520	ALGAE	TRILOBITES AND BRACHIOPODS
PRECAMBRIAN ERAS	*PROTEROZOIC*		ALGAE	NO PROVEN ONES
PRECAMBRIAN ERAS	*ARCHEOZOIC*	4000+	NO FOSSILS FOUND	

FIGURE 7.—Geologic time chart (*age in millions of years.)

the same tree had been covered with stagnant water, the process of decay would have been slowed or entirely halted, and would have remained so as long as the same conditions prevailed. This is the way that peat bogs are formed—by the accumulation of vegetable material in a shallow depression that is more or less constantly filled with water.

Of course, there are other factors that have to be considered. If the water is not stagnant, then decay may proceed as on dry land, or if there is much of a current it will carry away the debris nearly as quickly as it is deposited. Even if the water is stagnant and sand or mud is deposited along with the plant fragments, only a carbonaceous shale or sandstone will be formed. But if the water is truly stagnant, and little or no sediment is being washed into the basin, then conditions are excellent for peat formation. This process occurs year after year, with new plants growing in and around the swamp constantly contributing their leaves, stems, seeds, and other organs to add another layer to the vegetable matter already present. In this manner, little by little, new layers are built up and the additional weight gradually compresses the lower layers, squeezing out the air until decay practically ceases. This material is then called **peat**, and the process may continue until a considerable thickness has accumulated. This was the first stage of coal formation.

The next step was for the coal swamp to start to sink. Then, as the near-by hills and mountains began to erode away, quantities of sediments such as clay, sand, and gravel were washed into the basin and gradually covered the peat beds. By the time a few hundred feet of sediment had been deposited, the enormous weight served to compress the peat even further, driving out the gases and some of the water, thereby producing **brown coal** or **lignite**. As the lignite was buried even deeper, and consequently kept at higher temperatures, it lost more of its volatile matter and changed into **bituminous** coal. Under greater pressure, caused by very deep burial or by movements of the earth's crust, it became **anthracite coal**. The overlying sediments gradually changed into solid rock.

As millions of years passed, the earth continued to change. The downward movement was reversed and the rocks and coal beds were elevated, sometimes even up into mountains. Often this movement was so gentle that the coal beds are now horizontal or flat, just as they were formed, but usually they are at somewhat of an angle, thereby recording the crustal movements which have taken place.

The criteria for coal swamp formation seemed to be a warm, moist climate for plant growth, abundant rainfall to provide water to fill the shallow swamps, and flat, poorly

drained land. The ideal conditions apparently have not existed since Carboniferous times, although the great Dismal Swamp of Virginia and North Carolina most nearly approximates them.

One question that is often asked is "How long did it take to form coal?" This is difficult to answer, but it has been estimated that it takes about one hundred years for a foot of old mature peat to form, and that it takes about three feet of this peat to make one foot of our common bituminous coals. Therefore, it would take some 1500 years for the accumulation of enough plant material to form a five-foot coal seam.

HOW TO COLLECT, PROCESS, AND STUDY FOSSIL PLANTS

A collecting trip is only as good as the advance preparation. Essential equipment includes: (1) a rock hammer, (2) road map, (3) topographic map, (4) a knapsack or box to carry collections, (5) newspapers and soft tissue, (6) labels or note-paper, (7) paper sacks, (8) chisels, (9) magnifying lens, (10) a small note-book and (11) a pick and shovel.

The most essential implement is either a geologist's or mason's hammer, preferably like the one shown in Figure 8,

FIGURE 8.—Common equipment used in collecting.

which has a flat face on one end and a thin cutting edge on the other. The thin edge will prove especially helpful in splitting layered rocks. The pick and shovel are used in loosening or digging out the larger rocks from outcrops.

Both a State road map and the appropriate topographic quadrangle are important accessories for recording the exact collecting location.

In making a collection, it is both desirable and necessary to procure as complete a set of the fossils present as is possible. For this reason, every small fragment is laid aside as it is found until the available collecting time is nearly exhausted. Then the specimens are examined and the better examples of each type represented are selected for preservation. A small 5- to 10-power hand lens or magnifying glass is indispensable in this operation. The excess fossils are left behind, but it is important that the relative abundance of each type be recorded in the note-book for future reference. Other equally useful notes would describe the occurrence of the fossils, the probable kinds, the geologic age or strata in which they occur, and so on. The form in Figure 9 provides a quick and handy method of recording pertinent data.

The selected specimens must be wrapped before they are transported to the home or laboratory. Those that are carried loose will certainly be scratched or broken, thus impairing their value. The small, more delicate specimens are wrapped in tissue paper, and the larger, more bulky ones in newspaper. The date, locality, and names of the collectors are written upon a small card, piece of paper, or on the wrapping paper and included in each package. This is especially important if more than one location is visited on the same day or if for some reason they can not be studied at once. It is advisable

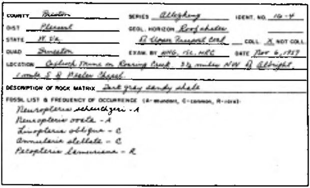

FIGURE 9.—Collection Card.

to wrap from the corner of the paper, much as the grocer wraps meat, to prevent unfolding while in transit. The smaller specimens are then packed into small paper bags and these, along with the larger rocks, are placed in either a knapsack or box for final transportation. It is preferable to pack the specimens in rows on edge, instead of flat, as additional insurance against breakage.

A small square-faced hammer and a series of small chisels should be available in the home or laboratory for trimming off superfluous material and for excavating partially exposed specimens. Broken specimens can often be repaired by using clear airplane dope as a glue.

When each rock is unwrapped it should be cleaned and permanently numbered. Perhaps the easiest and clearest way is to paint a small square with colored Butyrate (model airplane) dope which leaves a smooth writing surface upon drying. The number is then applied with an ordinary stock pen and India ink (Fig. 10). Specialized ball-point pens are also available for this work, as are carborundum pointed "pencils" which scratch the numbers directly into the rock surface.

All specimens in a single collection should bear the same collection number, as well as an individual specimen number which is generally assigned in sequence. The collection

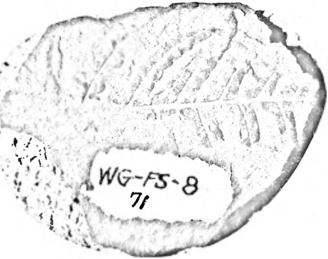

FIGURE 10.—A properly labeled specimen.

number is recorded in a record book along with the field data relating to it, such as the collection locality, collectors, date collected, the supposed age, and so on. This permanent record book is absolutely essential. If reliance is placed upon one's memory or upon loose paper labels, the specimens are apt to get mixed or misplaced and their scientific value impaired if not entirely destroyed.

One chief aim of paleobotanists has been to find evidence which would help establish ancestral connections with our modern plants, but so far little has been accomplished. Another goal has been to study and reconstruct the picture of ancient coal swamps. A thorough knowledge of these ancient floras provides a reliable basis for estimating the climate and geologic conditions that existed in past times. But perhaps the greatest success for fossil plants, outside of academic study and interest, has been in correlating the succession of sedimentary rocks by the fossil floras contained in them. For example, if a geologist finds a species of fossil plants in a bed of unknown age, and if this plant has hitherto been found only in the rocks of lower Mississippian age, then he is justified in believing that the rocks with which he is working are also of that age. Some fossils are of a very restricted time span and are correspondingly of greater value in the correlation of geologic units.

During the past 10 to 15 years, the study of the kinds and relative abundance of fossil plant spores (the science of **Palynology**) in various kinds of rocks has shown that they are of great value in stratigraphic correlations.

Still another tool is **coal petrology**, the study of the various plant constituents of coal, which indicates the specific chemical, physical, and combustion properties of any particular sample. This enables industry to estimate in advance how the fuel from a particular seam will react.

THE CLASSIFICATION OF PLANTS

Everything that man attempts has a certain amount of classification involved, and paleobotany is no exception. However, before we consider classifying yesterdays' plants we should perhaps consider the method in which living plants have been divided and/or united. In other words, the mechanism of plant classification.

All organisms, both plant and animal, are classified according to a system of binomial nomenclature, which means that each entity is given two names. These are called the generic and the specific names. They are derived from either Greek or Latin and once they are given, no other plant can be so designated, according to the International Rules of Botanical Nomenclature. The author who coined the name

or names has his last name placed just after the plant name in most literature.

Latin, the universal language of science, is preferred because it is a little-used language and, therefore, is not subject to great changes. No matter how many common names a plant may have in different countries, it has but one Latin name which is recognized and understood throughout the world.

In classifying plants the simplest unit is the **species**, a group of individuals that are obviously alike, such as all of the sugar maple trees. The second category groups together all of the various species that may exhibit certain features in common although differing to some degree among themselves. This is called the **genus**. For example, all of the different maples are lumped into the genus **Acer**, all of the different oaks into the genus **Quercus**, and so on. The obviously related genera are then brought together into a group called the **family**. In like manner, related families are grouped into **orders**, related orders into **classes** and related classes into a **phylum**. The final group includes all of the phyla and constitutes the plant kingdom. When the groups are very large, they are sometimes subdivided for convenience. It should be mentioned that no one of these categories is subject to precise definition, as each is more or less subjective in nature.

A modern classification of the sugar maple would be as follows:

Kingdom	Plantae
Subkingdom	Embryophyta
Phylum	Tracheophyta
Subphylum	Pteropsida
Class	Angiospermae
Subclass	Dicotyledonae
Order	Sapindales
Family	Aceraceae
Genus	Acer
Species	saccharum

Many systems of plant classification have been used, but the following is thought to best express the natural relationships of the plant kingdom and is the one used in most recent botanical text books:

Kingdom Plantae (Plants)

Subkingdom Thallophyta (Thallus plants)

Phylum Cyanophyta	Blue green algae	Algae
Phylum Chlorophyta	Green algae	Algae
Phylum Chrysophyta	Golden brown algae or diatoms	Algae
Phylum Pyrrophyta	Flagellates	Algae
Phylum Phaeophyta	Brown algae	Algae
Phylum Rhodophyta	Red algae	Algae
Phylum Schizomycophyta	Bacteria	Fungi
Phylum Myxomycophyta	Slime molds	Fungi
Phylum Eumycophyta	True fungi	Fungi

Subkingdom Embryophyta (with embryo)
Phylum Bryophyta
Class Musci .... Mosses
Class Hepaticae .... Liverworts
Class Anthocerotae .... Hornworts

Phylum Tracheophyta
Subphylum Psilopsida
Order Psilophytales .... Extinct
Order Psilotales

Subphylum Lycopsida
Class Lycopodineae
Order Lycopodiales .... Lycopodium
Order Selaginellales .... Selaginella
Order Lepidodendrales .... Extinct Lycopods
Order Pleuromeiales .. Extinct Middle Triassic plants
Order Isoetales .... Isoetes

Subphylum Sphenopsida
Class Equisetineae
Order Hyeniales .. Early Devonian plants
Order Sphenophyllales .. Coal age plants
Order Equisetales .... Horsetails

Subphylum Pteropsida
Class Filicineae
Order Coenopteridales .. Coal age plants ("ferns")
Order Ophioglossales .. Most primitive living ferns
Order Marattiales .. Ancient ferns still living
Order Filicales ...... Most modern ferns

Class Gymnospermae
Subclass Cycadophytae
Order Cyadofilicales .... Primitive seed plants
Order Bennettitales .... Mesozoic plants
Order Cycadales .... Living cycads

Subclass Coniferophytae
Order Cordaitales .... Paleozoic gymnosperms
Order Ginkgoales .. Mostly fossils, one living species
Order Coniferales .. Most living gymnosperms
Order Gnetales .. Most advanced gymnosperms

Class Angiospermae
Subclass Dicotyledoneae } Modern broad-
Subclass Monocotyledoneae } leaved plants.

Although the task of classifying living plants seems difficult, the problems involving fossil plants are even more complex. Fossils are rarely preserved in their entirety, and each

individual fragment, such as a leaf or stem, when first discovered is assigned a Latin generic name. Such genera are called **form genera** to distinguish them from a more natural genus, and they can not be assigned to a family. Whenever separate fragments named as form genera are found attached to other form genera (such as leaves to a stem), then the oldest published name has priority for both structures. Nevertheless, the form genus name is usually retained for naming the separate detached parts even after they have been proved to belong to the same plant. In some cases a plant will have seven or eight names for the various organs.

It is very difficult for any beginner to attempt to attach specific names to fossil plants. In fact, the literature is filled with blunders committed by "specialists". However, if we stop to consider the difficulties that would be involved in attempting to determine the specific identity of each fragment of a basket of chopped-up leaves and stems of modern plants, we can more readily appreciate the greater possibility of error in attempting to name imperfectly preserved fossil fragments. In addition, there is no reason to suspect that fossil plants did not vary from place to place and even within different parts of the same plant just as our modern plants do. With due care, a trained paleobotanist can produce trustworthy results from intensive study, but dozens of individual specimens should be examined before any conclusions are reached.

The fossil plants discussed in this publication, for easy reference, are listed alphabetically under the headings stems, leaves, and cones and seeds.

FOSSIL STEMS

Calamites

(Fig. 11)

The Calamites, which ranged throughout the coal ages, are represented in our modern floras by the single genus **Equisetum**, the horsetails. They are characterized by having jointed stems, branches, and cones. The foliage occurs in whorls at the joints or nodes. Three subgenera are often separated according to the mode of branching—**Stylocalamites**, branches few and irregularly scattered: **Calamitina**, branches in whorls, but only at certain nodes; and **Eucalamites**, branches at every node.

Many of the Calamites reached tree size. The fragmentary nature of the remains makes it difficult to give complete measurements, but trees up to 30 feet tall were certainly present. They probably grew in thick stands, much as our present horsetails do, on muddy or water-covered flats.

The stems were commonly preserved as pith casts. These were formed when the large pith broke down, forming a cavity from one node to another, into which sediment infiltrated as the plant was buried. Later, as the surrounding wood was rotted or turned into coal, the hardened sediment remained as a cast. Therefore, the surface ribs and grooves on the fossils correspond not to the external features of the plant, but to the woody strands which projected into the pith. The nodes are clearly marked on the casts and upon close examination one can see a small oval dot, which represents a specialized tissue, just below the nodal line on the upper end of each ridge. This often helps in orienting small specimens. It perhaps seems odd that the smaller, tapered end was the base and not the tip of the branches until we remember that our specimens are pith casts and that very little pith would be developed at branch attachments because of strength requirements (Plate 1, Fig. 1).

The leaves, found in whorls on the smaller branches, are termed **Annularia** (Plate 6, figs. 1-4) and **Asterophyllites** (Plate 6, fig. 5).

Smooth, non-segmented roots were often produced from the lower nodes as well as on the underground noded "rhizomes". Quite often they are referred to as **Pinnularia**.

The cones were all segmented, and the various kinds (**Calamostachys, Palaeostachys, Cingularia, etc.**) can be identified with certainty only when the internal structure is preserved.

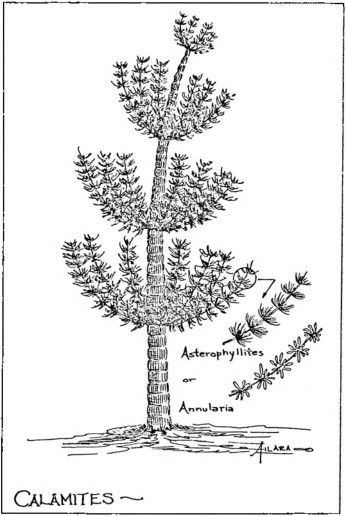

FIGURE 11.—Reconstruction of Calamites (redrawn from various sources by C. M. Ailara).

Lepidodendron

(Fig. 12)

This genus, which apparently evolved sometime during the Devonian Period, was a chief component of the Carboniferous coal swamps and apparently became extinct during Permian time. The plants generally resembled our present day "ground pines" (**Lycopodium**) in habit, but exceeded them enormously in size—some being comparable to our existing forest trees. The main stem was vertical, often rising to a height of 100 feet before reaching the branches which always forked in pairs.

The leaves, called **Lepidophyllum** when found alone, are linear structures from about 3 to as much as 40 inches long, much resembling extended pine needles (Plate 3, fig. 1). When the leaves were shed, the bases remained attached to the stem surface forming the persistent leaf cushion which is the most obvious distinguishing feature of the genus (Plate 3, fig. 4). Different names are often applied to stems which have had the outer layers removed by decay before preservation, thus appearing to have a different type of leaf scar.

The cones belong to the form genus **Lepidostrobus** and vary considerably in size according to species, the lengths ranging from about an inch to a foot, and the widths from ½ to at least 3 inches. They greatly resembled the spore-bearing cones of our modern lycopods (Ground Pine). When the individual cone scales are found as fossils, they are called **Lepidostrobophyllum**.

The roots of **Lepidodendron**, known as **Stigmaria**, are commonly found in the underclay or bottom rock of coal seams where they grew in the swampy ground. They are characterized by circular pit-like scars often surrounded by a raised rim. The scars mark the point of attachment of the rootlets, which spread into the mud on all sides (Plate 2, figs. 1, 2 and 4).

Lepidophloios is a name customarily given to fossil lycopod stems in which the leaf bases are wider than high, and which bear the leaf scar near the margin rather than in the center (Plate 3, fig. 3).

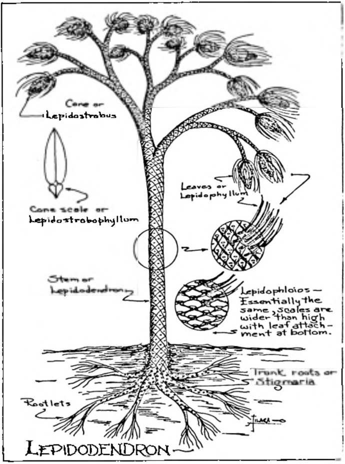

FIGURE 12.—Reconstruction of Lepidodendron (redrawn from various sources by C. M. Ailara.)

Psaronius

(Fig. 13)

Psaronius is a genus of Paleozoic tree ferns which ranged from the Mississippian to the Triassic Period, reaching their peak in the lower Permian. They reached heights of 40 feet or more and diameters of at least 3 feet.

The fronds probably had leaves of the **Pecopteris** type (Plates 17 and 18) (they have never been found attached), which were borne in a crown at the top of the trunk. The stem was covered by numerous roots, which were embedded within a mass of hairlike structures and actually provided most of the strength of the stem.

Sigillaria

(Fig. 14)

Sigillaria was one of the more important groups of Paleozoic plants, although they were more or less restricted to the Mississippian and Pennsylvanian Periods. They were among the largest of the trees growing in the forests of that time, with some being as much as 6 feet in diameter at the base. They differed from **Lepidodendron** in that the stem tapered upwards as an unbranched column for as much as 100 feet, with the dome-shaped apex bearing the leaves, thus greatly resembling our modern palm trees. In some species the upper trunk was occasionally divided into two or more portions, as is shown in the reconstruction.

The leaf scars are typically arranged in vertical series with adjacent scars alternating with one another. (In **Lepidodendron** the scars are in a spiral around the trunk). The form of the scar varies greatly, but, as a rule, they are hexagonal in outline with the angles more or less rounded (Plate 2, fig. 2). In instances where the outer layers rotted away before preservation, the scars may appear differently according to how deeply the decay had progressed. Such fossils are often placed in different form genera, such as **Syringodendron** (Plate 2, fig. 3).

The linear leaves are called **Sigillariophyllum** when found detached, but it is a rare occurrence when they can be distinguished from those of **Lepidodendron.**

Sigillaria produced its cones on short stalks which, when shed, left circular scars with a surrounding groove on the trunk. Although they are called **Sigillariostrobus**, it is difficult to separate detached cones from those of **Lepidodendron** unless they are petrified.

The underground portions are, for practical purposes, identical with those of **Lepidodendron**, and are called **Stigmaria** and stigmarian rootlets.

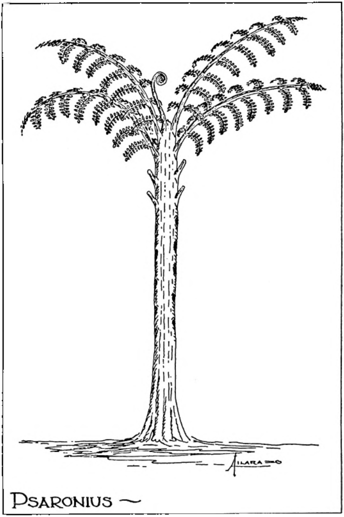

FIGURE 13.—Reconstruction of Psaronius (redrawn from various sources by C. M. Ailara.)

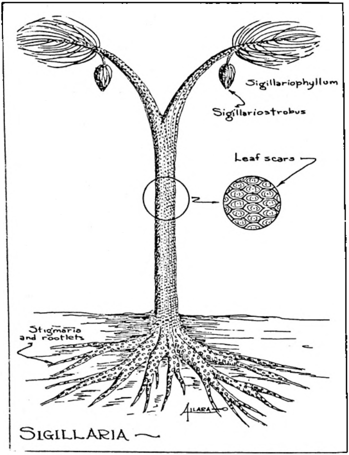

FIGURE 14.—Reconstruction of Sigillaria (redrawn from various sources by C. M. Ailara.)

Other Woods in Coal

Many coal "dumps" are literally covered with small pieces of fossilized wood. Figure 2 shows a few such logs found in association with a coal seam. Figure 3 is a photograph of a thin section prepared from a fossilized log to show the excellently preserved structure.

FOSSIL LEAVES

It is probable that the compressions or impressions of fern-like foliage, found so exquisitely preserved on mine

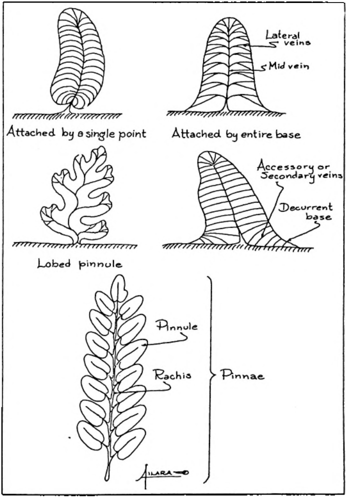

FIGURE 15.—Pictorial glossary showing key characters of fossil foliage.

dumps, are better known to the casual observer than are any other fossils. The character of the leaves was such that the form and veination are sometimes found perfectly preserved and, therefore, can be used as characters in classification (Fig. 15).

The following key can be of value in determining the correct generic name for a fossilized leaf. It is constructed so that there is a choice of two contrasting characters at each step. To proceed, select the more nearly correct number "1" entry and then move on to the next stage of the keys as directed—either 2 or 4. The elimination of one set of characters at each stage will eventually lead to a name. The identification can then be compared to the proper description and illustrations for final confirmation.

KEY TO THE MAJOR TYPES OF STERILE FOSSIL LEAF GENERA THAT HAVE BEEN FOUND IN THE COAL MEASURES OF WEST VIRGINIA

1. Foliage arranged in whorls on jointed stems . . . (2)
1. Foliage not arranged in whorls on jointed stems . . . (4)

    2. Leaflets with one simple vein; more or less lance-shaped . . . (3)
    2. Leaflets with a repeatedly forking vein; wedge-shaped to broadly ovate. Sphenophyllum (Plate 21, figs. 1-4).

3. Leaflets flattened in plane of stem; leaves nearest stem parallel to stem. Annularia (Plate 6, figs. 1-4).
3. Leaflets not flattened in plane of stem; leaves cupping around stem. Asterophyllites (Plate 6, fig. 5).

    4. Foliage consists of large, irregularly lobed or highly dissected leaf-like structures—often made up of complicated tufts or small vari-shaped tongues, veins usually indistinct. Aphlebia (Plate 7).
    4. Not as above . . . (5)

5. Foliage consists of long, slender, strap-shaped leaves or pinnules . . . (6)
5. Foliage consists of fern-like fronds or separate pinnules detached from them . . . (7)

    6. Foliage consists of long, slender, strap-shaped leaves with numerous longitudinal veins, but no midrib. Cordaites (Plate 4, figs. 1 and 2).
    6. Foliage consists of long, strap-shaped pinnules, often deeply bifurcated, with a well-developed midrib giving off slender, lateral veins. (Only fragments of the complex frond are usually found). Megalopteris. (Plate 13, figs 1 and 2).

7. Fronds with entire pinnules (the more basal pinnules often show a slight lobation) . . . (8)
7. Fronds with lobed or dissected pinnules . . . (19)

    8. Pinnules attached to rachis by a simple point . . . (9)
    8. Pinnules attached to rachis by their entire base . . . (11)

9. Secondary veins forming a network; pinnules tongue-shaped. Linopteris (Plate 15, fig. 5).
9. Secondary veins not forming a network . . . (10)

10. Pinnules tongue-shaped, lateral veins arching from an indistinct midrib. **Neuropteris** (Plates 14, 15, and 16).
10. Pinnules circular. **Cyclopteris** (Plate 15, fig. 4, and Plate 16, figs. 1-4).
11. Mature pinnules usually, though not invariably, decurrent; with secondary veins . . . (12)
11. Mature pinnules not decurrent; no secondary veins . . . (17)
12. Accessory pinnae or pinnules between normal pinnae . . . (13)
12. No accessory pinnae or pinnules between normal pinnae . . . (15)
13. Pinnules scythe-shaped; intercalated pinnules half-round. **Lescuropteris** (Plate 12).
13. Pinnules not scythe-shaped . . . (14)
14. Pinnae nearly all the same size; pinnules with parallel margins, perpendicular to the rachis and non-decurrent (Pecopterish). **Callipteridum** (Plate 11, figs. 1 and 2).
14. Pinnae diminish in size in descending order; pinnules decurrent and usually at an angle to the rachis (Alethopterish). **Callipteris** (Plate 9).
15. Midvein indistinct, numerous veins entering pinnule from the rachis. **Odontopteris** (Plate 11, fig. 3).
15. Midvein distinct, pinnules free or united . . . (16)
16. Lateral veins numerous, at near right angles to the midveins; midvein heavy—represented by a groove on the upper surface, a ridge on the lower. **Alethopteris** (Plate 5).
16. Lateral veins not numerous, at an angle to the margin; midvein distinct, but not heavy enough to be represented as a groove or ridge. Base of pinnules often contracted. **Danaeites** (Plate 8).
17. Midvein distinct, one vein enters pinnule, pinnules free or united at base . . . (18)
17. Midvein indistinct, numerous veins entering pinnules from rachis, pinnules free. **Odontopteris** (Plate 11, fig. 3).
18. Lateral veins leave midrib at slight angles, numerous, light; margin of pinnules parallel or nearly so. **Pecopteris** (Plates 17 and 18).
18. Lateral veins few, heavy, traversing at a steep angle to the apex where they often terminate in 2 or 3 more or less prominent teeth. **Aloiopteris** (Plate 10, figs. 5 and 6).
19. Accessory pinnules or pinnae between normal pinnae. **Callipteris** (Plate 9).
19. No accessory pinnules or pinnae between normal pinnae . . . (20)
20. Midrib noticeable at least ½ or more the length of the pinnule . . . (21)
20. Midrib hardly discernible and less than ½ the length of the pinnule . . . (23)
21. Pinnules somewhat triangular; basal pinnules on lower side of pinnae often bilobed or trilobed; rachis transversely ribbed. **Mariopteris** (Plate 20, figs. 1 and 5; Plate 21, fig. 5).
21. Pinnules rounded to broadly linear . . . (22)
22. Segments small, pinnule often on short stalk. **Sphenopteris** (Plate 20, figs. 2 and 3).
22. Segments large. **Aneimites**. (Distinctly three-lobed is **Triphyllopteris**.) (Plate 19, figs. 2-6).
23. Segments rounded, evenly and deeply cut to rachis. **Diplothmena** (Plate 19, figs. 1 and 2; Plate 20, fig. 4; and Plate 21, fig. 6).
23. Segments irregularly shaped and dissected. **Eremopteris** (Plate 10, figs. 1-4).

Alethopteris

(Plate 5)

Alethopteris was the foliage of "seed-ferns". These leaves are large and the thick, leathery, oblong pinnules are attached to the rachis by their entire, usually **decurrent** and often **confluent**, bases. The midvein extends through the entire length of the leaflet. It is prominent on the lower surface, but is usually seen as a heavy groove on the upper side. The numerous lateral veins are given off nearly perpendicular to the main vein and pass directly, with or without forking, to the margins. Unlike **Neuropteris**, with its single vein entering the base, accessory veins pass directly from the rachis into the pinnule.

It is not known at this time just how many species occur in West Virginia, but specimens can be found throughout the Pennsylvanian System.

Alloiopteris

(Plate 10, fig. 5)

This form genus is used to classify the fronds which are intermediate between **Pecopteris** and **Sphenopteris**. They are characterized by having small, alternately arranged, sometimes decurrent pinnules that are more or less fused together laterally. A single vein enters the pinnule and forks two or three times, the veinlets passing to the **margin** where they often terminate in three somewhat prominent teeth. An abnormal, deeply dissected pinnule (**Aphlebia**) typically occurs at the base of each pinnae. Fertile pinnules of this genus are classified as **Corynepteris**.

This fossil is relatively rare in West Virginia, but sterile pinnae are quite often found in the Pocahontas and New River Groups of the Pottsville Series.

Annularia

(Plate 6, figs. 1-4)

Annularia is the name applied to one type of foliage borne on **Calamites**. The leaves occur in whorls and radiate from the nodes of the smaller stems. They are usually somewhat lance-shaped, unequal in length and contain just one central vein. In addition, they have convex leaf margins, the individual leaflets in the whorl are fused into a sheath at the base, and the plane of the whorl is parallel to the stem.

The illustrations are of three of the more common ones to be found in West Virginia, but at least five species have been recorded from throughout the coal-bearing horizons of the State.

Aphlebia

(Plate 7)

Aphlebia are large, leaf-like structures which probably represent modified pinnules. They are often deeply lobed or lacerated with an irregular type of veination, or with wrinkles or folds which simulate veins.

They are often found in conjunction with the pecopterid and neuropterid foliage, on which they occurred at the base of the pinnae. It has been conjectured that they were protective devices for young buds.

Asterophyllites

(Plate 6, fig. 5)

This form genus is also reserved for the leaves of **Calamites.** They are similar to **Annularia** as they are borne in whorls, are united inconspicuously into a sheath at the base, and have a single central vein. However, they differ by being equal in length, by cupping around the axis or stem, and by having the leaf margins parallel.

There are at least three species in West Virginia occurring from the Pocahontas Group of the Pottsville Series up into the Dunkard strata.

Callipteridium

(Plate 11, fig. 1)

Callipteridium fragments are very similar to, and are often confused with, **Alethopteris.** The pinnules are only very slightly, if at all, decurrent, the midvein reaches only about two-thirds of the way to the apex and the tip is more blunt than in **Alethopteris.** However, the key characteristic, and one which must be present for positive identification, is the occurrence of small accessory pinnae on the rachis between the normal pinnae. It is a seed fern.

It is not known just how many species of **Callipteridium** occur in West Virginia because the specimens are seldom large enough to insure accurate identification. They occur throughout the upper third of the Pennsylvanian System.

Callipteris

(Plate 9)

Callipteris in North America is a variable genus with alethopterid-like pinnules, attached by the entire base, which occur on both pinnae and rachis. The pinnules which occur between normal pinnae are termed "intercalary pinnules". The pinnae are usually attached obliquely to the main rachis

and decrease in size in descending order. This plant was reported from two or three locations in West Virginia about 60 or 70 years ago, but recent workers have not collected the plant in the State. The illustration is from the original paper. It was probably a seed-fern.

Cordaites

(Plate 4, figs. 1 and 2)

Cordaites is the name given to compressions of long, slender, strap-shaped stemless leaves of several sizes. These possess no midrib, but numerous veins traverse the leaves longitudinally. They were borne in spiral sequence on the smaller branches of a Carboniferous gymnosperm. Complete specimens are rare in West Virginia.

Danaeites

(Plate 8)

The pinnules of **Danaeites** are oblong, blunt, and sometimes, though not always, connected laterally at the bases. The lateral veins arise from a thick midrib and pass at an angle to the margin, either simply or forking once. The fertile pinnules bear the fructifications in linear series from the midrib to the margins.

Danaeites has been found in the Monongahela and Dunkard strata in West Virginia.

Lescuropteris

(Plate 12)

Lescuropteris is identified by the scythe-shaped acute pinnules which have the lower veins emerging from the rachis and the upper ones emerging alternately from the thin midvein. The rachis is winged by the intercalation of half-round leaflets between the bases of the pinnae. This plant has been found in the roof shales of the Pittsburgh Coal and was probably a seed-fern.

Megalopteris

(Plate 13, figs. 1 and 2)

The frond of **Megalopteris** consists of strap-shaped pinnules that are often deeply bifurcated. Each contains a strongly developed midrib which gives off very fine lateral veins. This plant is seldom collected in West Virginia and when found is usually in a fragmentary condition.

Neuropteris

(Plates 14, 15, and 16)

The neuropterids were generally seed-bearing plants and, therefore, are of little relation to the true ferns which reproduce by spores, although they were once classified as such. They are often referred to now as seed-ferns. The leaves or pinnae were usually large with tongue-shaped leaflets or pinnules that were often, but not always, heart-shaped at the base and were attached to the rachis by a short stalk. The apex of the pinnae has either a large terminal leaflet or two smaller ones. One main vein enters the base of each leaflet where it gives off lateral veinlets that curve outward, sometimes forking, to the usually unlobed margins. (Some species apparently began to evolve more rapidly in the upper Paleozoic, and often are found to be lobed or lacerated as is shown in Plate 15, figs. 1 and 2, and Plate 16, fig. 5).

Many authors have reported **Neuropteris** from West Virginia, but there is no way, short of a lengthy critical study, to determine exactly how many species are actually present. However, one or another species occurs from the lower Pottsville through the Dunkard formations. This is probably the most abundant of the "fern-like" plants, being seriously rivaled for the title only by **Pecopteris**.

In some cases, circular leaflets, without a median vein, were attached to the main rachis in much the same fashion as stipules are in modern plants. When found separately, these are classified in the form genus **Cyclopteris** (Plate 16, figs. 1-4).

Linopteris

(Plate 15, fig. 5)

The pinnules of **Linopteris** are nearly the same as **Neuropteris**, the only difference being that the veins form a network. It is a seed-fern.

NOTE — The late Walter Gothan,[3] one of the world's foremost paleobotanists, devised and published a more natural classification for the Neuropterid group—one which, in time, will probably supersede the above classification. The following form genera were given in the last published revision:

I Neuropterids imparipinnate (one terminal leaflet)
  - (a) Regular veination —— Imparipteris
  - (b) Veins in network —— Reticulopteris

II Neuropterids paripinnate (two terminal leaflets)
  - (a) Regular veination —— Paripteris
  - (b) Veins in network —— Linopteris

[3]Gothan, W. (1953) Die Steinkohlenflora der westlichen paralischen Steinkohlen-reviere Deutschlands. Lief. 5: Beihefte Geol. Jahrb., Heft 10, pp. 1-83.

Odontopteris

(Plate 11, fig. 3)

This genus probably evolved from **Neuropteris** through a breaking up of the pinnules into segments, and thus is a seed-fern. It is characterized by entire pinnules that are attached by their whole base (they often appear decurrent and sometimes the base of the pinnule is slightly narrowed), and by the several veins which enter the pinnule from the rachis and fork from one to several times before passing to the margin.

Various species of **Odontopteris** range from the Pottsville through the Dunkard in West Virginia.

Pecopteris

(Plates 17 and 18)

Pecopteris is one of the largest and most interesting of the artificial, or form, genera, and undoubtedly serves as a provisional genus for plants having many different natural affinities. Some members were seed-ferns, while a considerable variety have been found to bear spore-producing fructifications. When fertile specimens are described, they are then removed from the provisional genus, **Pecopteris,** and given special generic names, although **Pecopteris** is often retained for the sterile fronds.

This genus is characterized by relatively small pinnules with usually entire, parallel, or slightly curved margins that are attached to the rachis by their whole base (in some species the pinnules are laterally attached to one another). A single vein enters the base and extends to the tip of each pinnule. Lateral veins are few and they pass, either simple, forked, straight, or curved, to the margin. The main rachis of the frond is naked between the pinnae and often has characters such as dots, scales, or lines that are useful in classification.

Many dozens of different species have been reported to occur in West Virginia, although undoubtedly many of them just represent different stages of maturity or variations of the same plant. They occur in rocks of Pottsville through Dunkard age, but they first became common in Conemaugh strata.

Sphenophyllum

(Plate 21, figs. 1-4)

Sphenophyllum is a genus of segmented or articulated plants similar to **Calamites.** However, instead of being huge trees, they were small plants growing on the forest floor.

Indeed, some representatives may have been little more than slender vines. The name is derived from the wedge-shaped leaves which occur in superposed whorls of six, eight or nine at the nodes of the stem, often varying in size and degree of dissection on different portions of the same stem. They are typically wedge-shaped, with the acute angle at the base, to more or less egg-shaped. The outer margin may be either concave, convex, or straight, and may be either deeply lobed, unlobed, or with blunt or pointed teeth. One vein enters the base of the leaf and divides equally several times, with the small veinlets terminating at the outer margin.

Some 21 species have been described from North America, of which at least 6 have been found scattered throughout the coal measures of West Virginia.

OTHER GENERA

The following five genera of fossil plants are variously interpreted by different authors. Some of them were originally conceived as separate genera solely to distinguish between fronds with different modes of branching. Undoubtedly all of them include members of widely differing families possessing pinnules of the same general type. However, even though the marginal species of various genera seem to intergrade, the characters given herein have been selected to establish what is generally considered to be the "typical" form of each genus.

Mariopteris

(Plate 20, figs. 1 and 5, and Plate 21, fig. 5)

This genus was erected to contain those fossils in which the naked stem forks equally into two divisions, with each fork again dividing equally before giving off pinnae. The forks on each side of the plant divide in the same manner, thus keeping the overall plant symmetrical. The heavy leathery pinnules are somewhat like **Pecopteris** in that they are usually attached by their entire base and are sometimes joined laterally, but they are always decurrent, have either wavy or lobed margins and are somewhat triangular. A rather strong midvein, which extends nearly to the tip of the pinnule, gives off lateral veins at an acute angle which forks in passing to the margin.

One characteristic often present is that the basal pinnule on the lower side of each pinnae is somewhat larger than the others, and is usually rather prominently two-lobed.

It is difficult to separate species in this genus because the pinnules vary in size and form when the youngest are contrasted with the oldest, as well as in different portions of the branched frond.

Mariopteris is found throughout the Pennsylvanian System of West Virginia. It is a seed-fern.

Diplothmena

(Plate 19, figs. 1 and 2, Plate 20, fig. 4, and Plate 21, fig. 6)

It is impossible to draw a sharp line of distinction between **Mariopteris** and **Diplothmena**. The genus was originally established to include the fernlike species in which the frond forked once equally and thereafter lost the regular symmetry of **Mariopteris**. However, later authors have pointed out the intergradation of such characters. The pinnules are usually not as leathery appearing as in **Mariopteris**, they have a narrow point of attachment to the rachis, and are usually more or less evenly and deeply lobed. The veins are nearly the same as **Mariopteris** except that the midvein is inconspicuous.

Diplothmena is often found in the Pennsylvanian rocks of West Virginia. It is a seed-fern.

Sphenopteris

(Plate 20, figs. 2 and 3)

Sphenopteris is a large and diversified group. It is characterized by small pinnules which are contracted at the base and which often attach to the rachis by a short stalk. They are oval or oblong in outline with a more or less recognizable midvein which gives off lateral veins in a fan-like arrangement. The lateral veins fork from one to several times before passing to the tips of the lobes. The name **Lyginopteris** is often applied to the characteristic stems which bore certain species of **Sphenopteris** foliage (Plate 4, fig. 3).

Sphenopteris is commonly found in the lower portions of the Pottsville Series, but also occurs at higher levels. Some species were ferns and some were seed-ferns; the affinity of others is not known.

Eremopteris

(Plate 10, figs. 1-4)

Eremopteris often resembles **Sphenopteris** in over-all appearance, but the pinnules are usually larger, more irregularly shaped and dissected, contain no midrib, and are decurrent.

This genus is known to occur from the lower portion of the Pottsville Series through the Monongahela Series.

Aneimites

(Plate 19, figs. 3-6)

The pinnae of **Aneimites** are rather delicate-appearing with fairly large pinnules. The tip is usually separated intc

two or more rounded segments, with the dividing cleft being of varying depths. The veins fork equally and radiate throughout the pinnule.

Aneimites, also a seed-fern, is characteristic of the lower Carboniferous, or Mississippian, strata in West Virginia. The large three-lobed form is usually assigned to **Triphyllopteris.**

FOSSIL SEEDS, CONES AND OTHER DETACHED FRUCTIFICATIONS

Aulacotheca

(Plate 22, fig. 7)

Aulacotheca was a pollen-bearing organ that is quite often collected in association with **Neuropteris** foliage in the Pocahontas and New River Groups of the Pottsville Series. It is found as an oval, elongated, striated compression (about one inch long) that tapers to a point both at the base and at the apex.

Carpolithus

(Not illustrated)

Carpolithus is essentially a smooth, rounded, egg-shaped compression or cast with the over-all appearance of a seed, but with no definable distinctive characters. It is common in West Virginia.

Dolerotheca

(Plate 23, figs. 1 and 2)

Dolerotheca is a large and unusual pollen-bearing organ. The original form was a bell-shaped structure enclosing numerous tubular, elongate, radially aligned sporangia. In the roof shales of the Pittsburgh Coal they are found in association with **Alethopteris** foliage, and present at least three external appearances according to the surface exposed. It is a rare fossil.

Holcospermum

(Plate 22, fig. 6)

Holcospermum is a compression of a seed with more or less strongly developed ribs which was originally of the **Trigonocarpus** type, but in which the outer layers were either completely or partially destroyed before preservation. The ribs were caused by protruding resistant tissue. These seeds are common.

Trigonocarpus

(Plate 22, figs. 1-4)

The form genus **Trigonocarpus** was founded to include casts of radially symmetrical seeds characterized by three prominent longitudinal ribs.These seeds vary from less than ½ inch to as much as four inches long and up to 1½ inches in diameter. They were the seeds of "tree ferns".

It is possible to find **Trigonocarpus** casts at almost any horizon where fossil plants are abundant.

Fossil Cones

(Plate 13, figs. 3 and 4. Plate 23, figs. 3 and 4)

Fossil cones are rather rare, and thus only long and diligent searching will provide a representative collection. This difficulty is coupled with the fact that accurate identification of compression material is virtually impossible. Cones showing articulations are usually assignable to one of the calamitean form genera, but accurate identification of any cone is possible only when it is structurally preserved or has abundant sporangia which still contain spores. Therefore, the casual collector can best label his specimens simply as "cones", or contact a professional paleobotanist for help and information.

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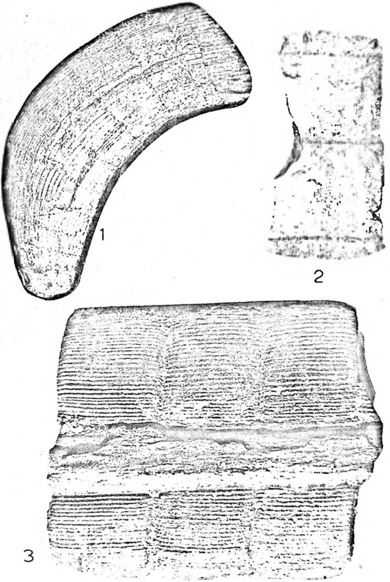


PLATE 1. Calamites.

1. **Calamites** stem cast. Note tapering end, which was the point of attachment, and the dots of special tissue (infranodal canals) near the top of each node. (X 1/2)
2. **Calamites** stem compression. (X 1/2)
3. **Calamites** stem cast. (X 2/3)

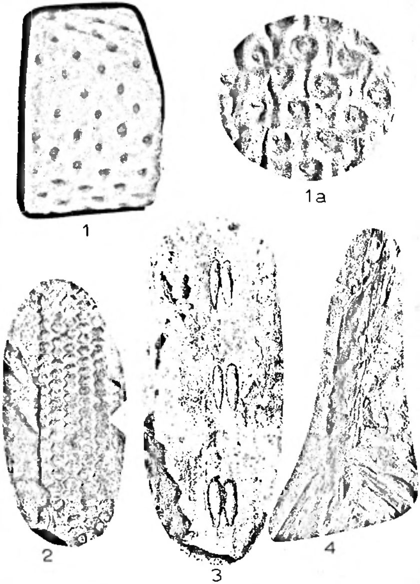


PLATE 2. Sigillaria, Stigmaria, and Syringodendron.

1. Small section of **Stigmaria** (X 1/2)
1a. Enlarged section of same. (X 2)
2. Section of **Sigillaria** stem showing vertical arrangement of leaf scars. (X 1)
3. Section of **Syringodendron**, a **Sigillaria** that had the outer layers removed during fossilization. (X 1)
4. A root, commonly attached to **Stigmaria**. (X 1)

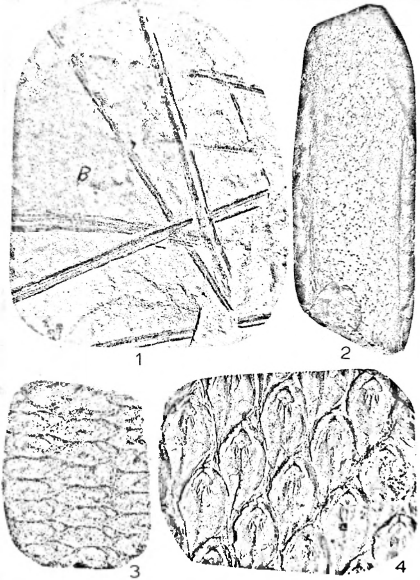


PLATE 3. Lepidodendron, Lepidophloios, and Pecopteris Stem.

1. Leaf type borne by **Lepidodendron.** (X 1)
2. **Pecopteris** stem. Note the punctations. (X 1)
3. **Lepidophloios** showing scars. (X 1)
4. **Lepidodendron** showing raised leaf scars. (X 1)

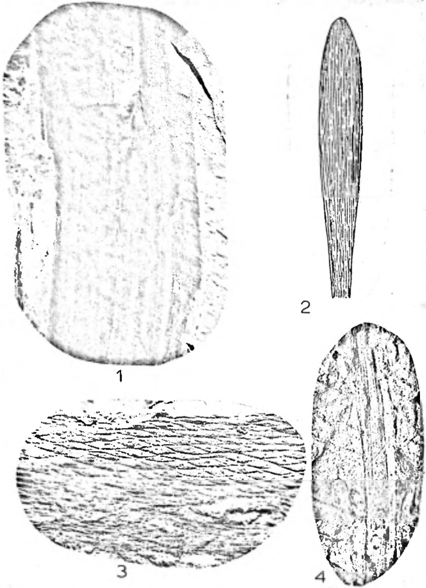


PLATE 4. Cordaites and Lygenopteris.

1. Fragment of **Cordaites** leaf. (X 1/2)
2. Drawing of **Cordaites** leaf showing over-all shape. Greatly reduced.
3. Portion of **Lygenopteris** stem. (X 1)
4. A striated stem. (X 1)

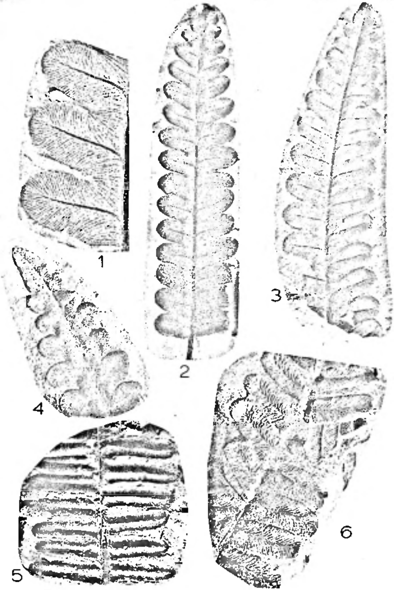


PLATE 5. Alethopteris.

1-6. Common forms of Alethopteris. All natural size except 1, which is X 2.

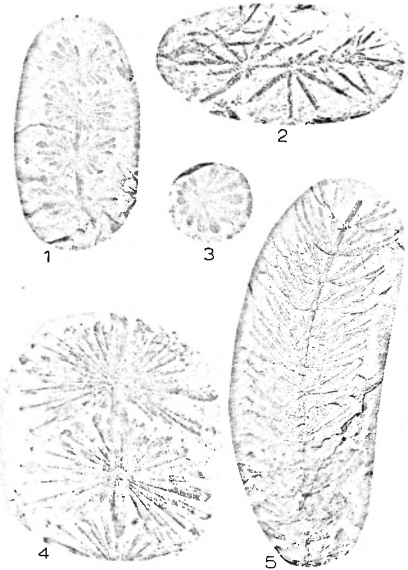


PLATE 6. Annularia and Asterophyllites.

1–4. Annularia. (X 1)
5. Asterophyllites. (X 1)

1

2

PLATE 7. Aphlebia.

1. Aphlebia. (X 1)
2. Drawing of Aphlebia. (X 1)

1a

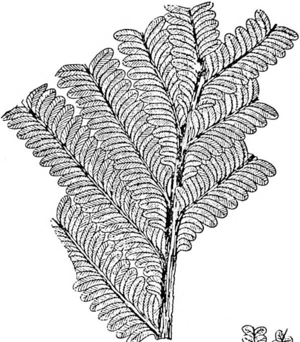
1

2

3

PLATE 8. Danaeites.

1. Sterile Danaeites frond. (X 1/4)
1a. Drawing of pinnule of same. The base is often constricted on both sides.
2. Fertile Danaeites. (X 1)
3. Danaeites frond with both sterile and fertile pinnae. (X 1)



1

1a

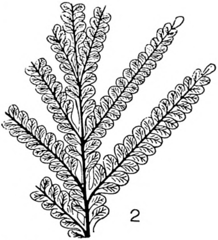


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PLATE 9. Callipteris.

1. Drawing of **Callipteris conferta** from Fontaine and White (**Permian Flora, Pa.** Geol. Survey, 1880) (X 1)
1a. Enlarged pinnule of same.
2. Section from upper part of a compound pinnae. (X 1)

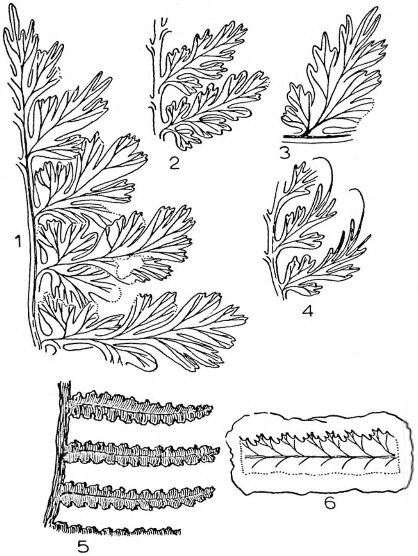

PLATE 10. Alloiopteris and Eremopteris.

1–4. Drawings of Eremopteris pinnules. Enlarged.
5. Drawing of Alloiopteris showing pinnule form. (X 1)
6. Drawing of Alloiopteris pinnule showing venation. Enlarged.

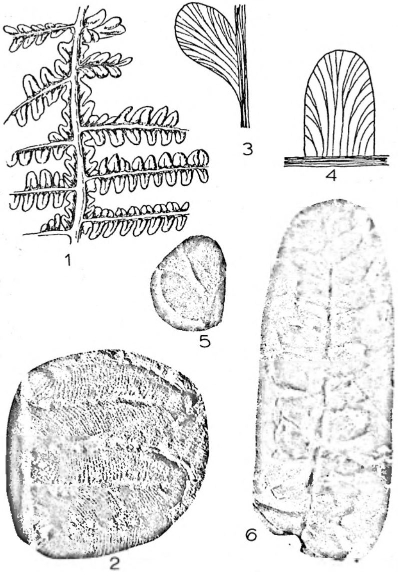

PLATE 11. Callipteridium and Odontopteris.

1. Drawing of *Callipteridium*. Note pecopterid appearance and small intercalated pinnules. (X 1)
2. *Callipteridium* pinnules. (X 5)

3–4. Drawings of common *Odontopteris* pinnules. (X 2)

5–6. *Odontopteris*. (X 1)

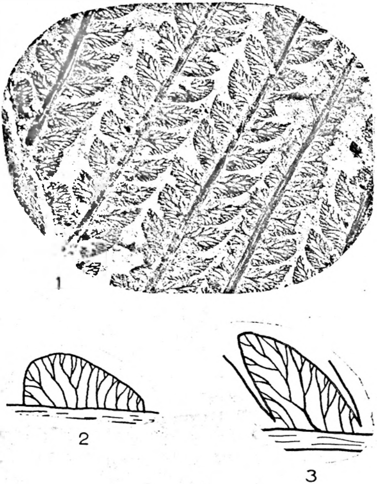

PLATE 12. Lescuropteris.

1. Lescuropteris. (X 2)
2. Enlarged intercalary pinnule.
3. Enlarged pinnule.

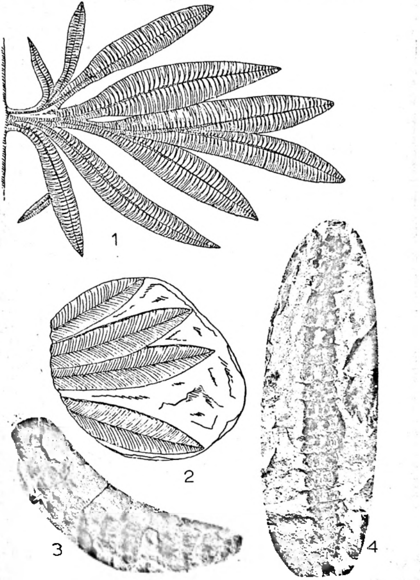

PLATE 13. Megalopteris and Fossil Cones.

1. Enlarged drawing of *Megalopteris* frond (after Lesquereux.)
2. Drawing of *Megalopteris* fragment. (X 1)
3–4. Fossil cones. (X 1)

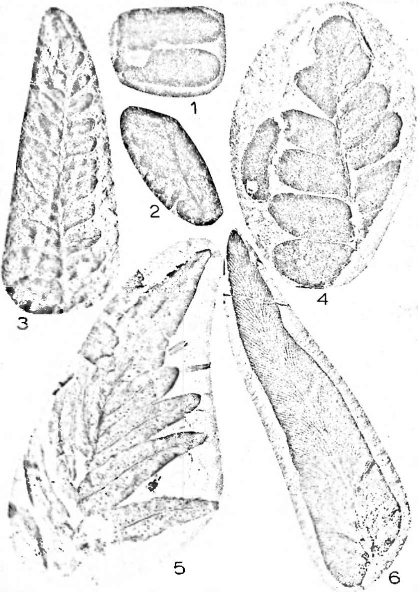

PLATE 14. **Neuropteris.**

1-7. Common forms of Neuropteris. (X 1)

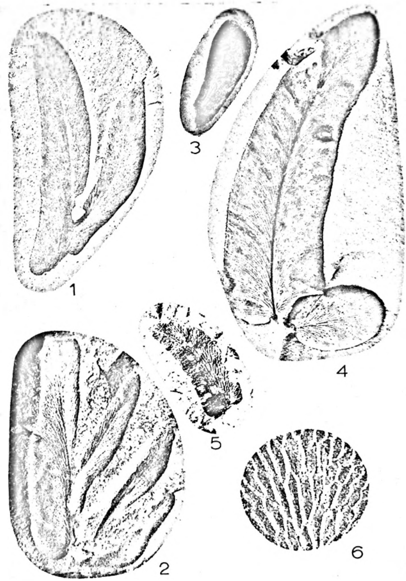

PLATE 15. Neuropteris and Linopteris

1-2. Polymorphic forms of **Neuropteris** pinnules. (X 1)
3. Detached fragment of **Neuropteris** showing odontopterid appearance. (X 1)
4. Common type of **Neuropteris** with attached **Cyclopteris** pinnule. (X 1)
5. **Linopteris** pinnule.
6. Enlarged **Linopteris** pinnule showing net venation. (X 16)

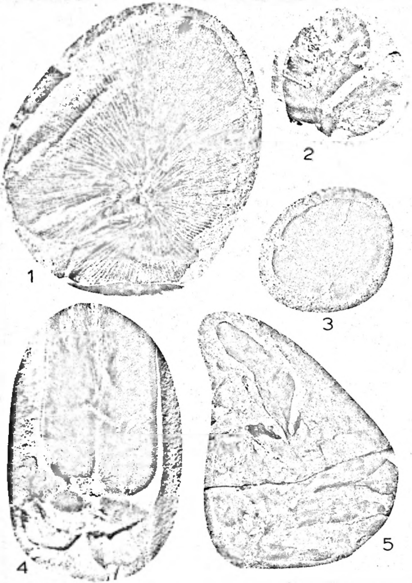

PLATE 16. Neuropteris and Cyclopteris.

1–3. Detached **Cyclopteris** pinnules which normally grew at the base of larger **Neuropteris** pinnules as in 4. (X 1)
4. **Cyclopteris** pinnules attached to **Neuropteris** pinnule. (X 1)
5. A single **Neuropteris** pinnule which has split into several lobes, thus appearing to be a different plant. (X 1)

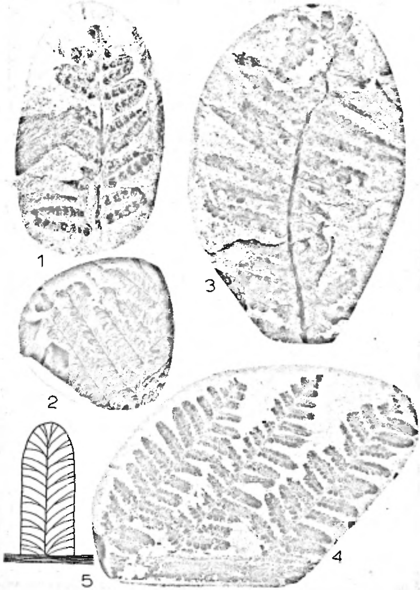

PLATE 17. Pecopteris.

1. Fertile Pecopteris. (X 1)
2-4. Common Pecopteris species. (X 1)
5. Enlarged drawing of Pecopteris pinnule to show one type of veination.

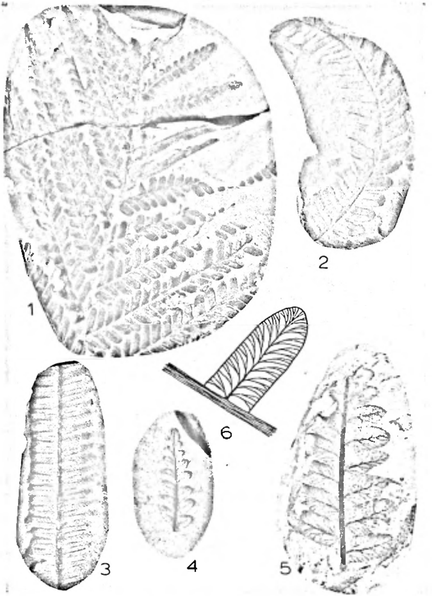

PLATE 18. Pecopteris.

1-5. Common forms of *Pecopteris*. (X 1)
6. Enlarged drawing of *Pecopteris* pinnule to show one type of veination.

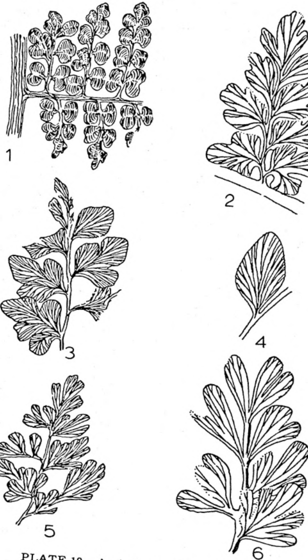

PLATE 19. Aneimites and Diplothmena.

1. Diplothmena. Slightly enlarged schematic drawing to show form.
2. Diplothmena. Enlarged schematic drawing to show veination.
3-6. Aneimites. Enlarged schematic drawings to show form and veination.

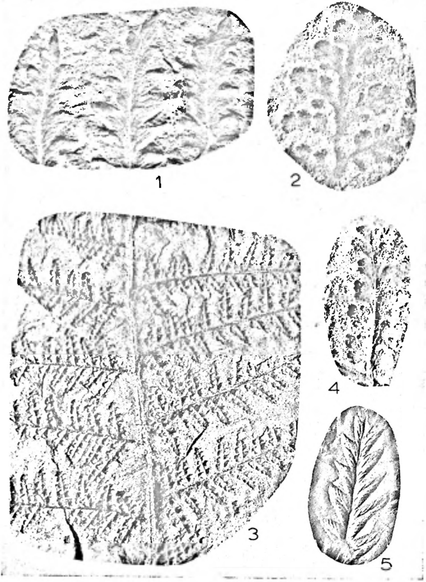

PLATE 20. Diplothmena, Mariopteris, and Sphenopteris.

1. Mariopteris. (X 1)
2. Sphenopteris. (X 4)
3. Sphenopteris. (X 1)
4. Diplothmena. (X 2)
5. Mariopteris. (X 1)

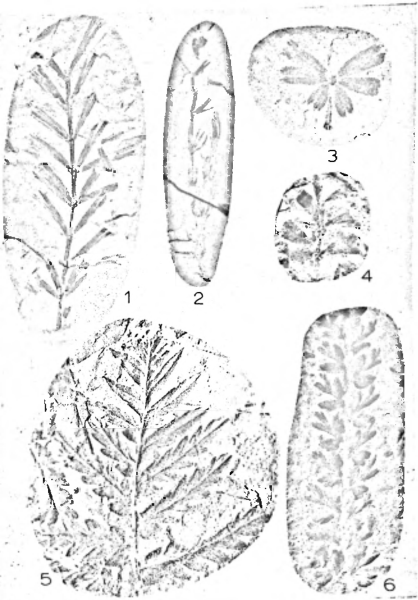

PLATE 21. Diplothmena, Mariopteris, and Sphenophyllum.

1-4. Common types of Sphenophyllum. (X 1)
5. Mariopteris fragment, near top of frond. (X 1)
6. Diplothmena fragment. (X 1)

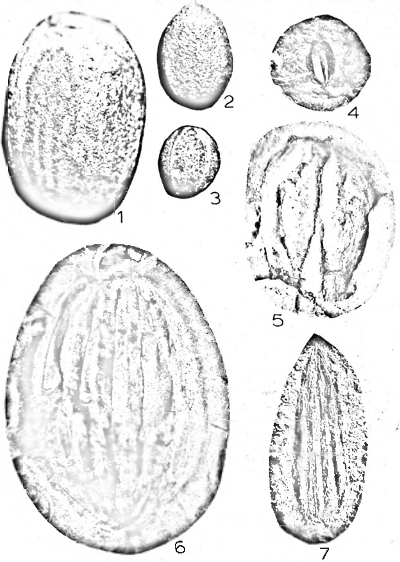

PLATE 22. Aulacotheca, Holcospermum, and Trigonocarpus.

1-4. **Trigonocarpus** seeds. (X 1)
5. Unassigned seed. (X 1)
6. A type of **Holcospermum** seed. (X 1)
7. **Aulacotheca**, a pollen-bearing organ. (X 3)

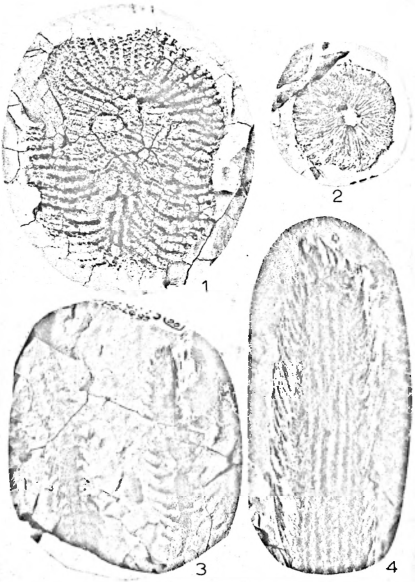

PLATE 23. Dolerotheca and Common Cones.

1. Dolerotheca compression. Note openings of tubes from which spores escaped. (X 1-1/2)
2. Dolerotheca compression showing upper side. Note point of attachment. (X 1)

3-4. Common cone types. (X 1)

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